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University of Toronto, Toronto

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VOL. XXV, No. 10 DECEMBER, 1931 WHOLE No. 209

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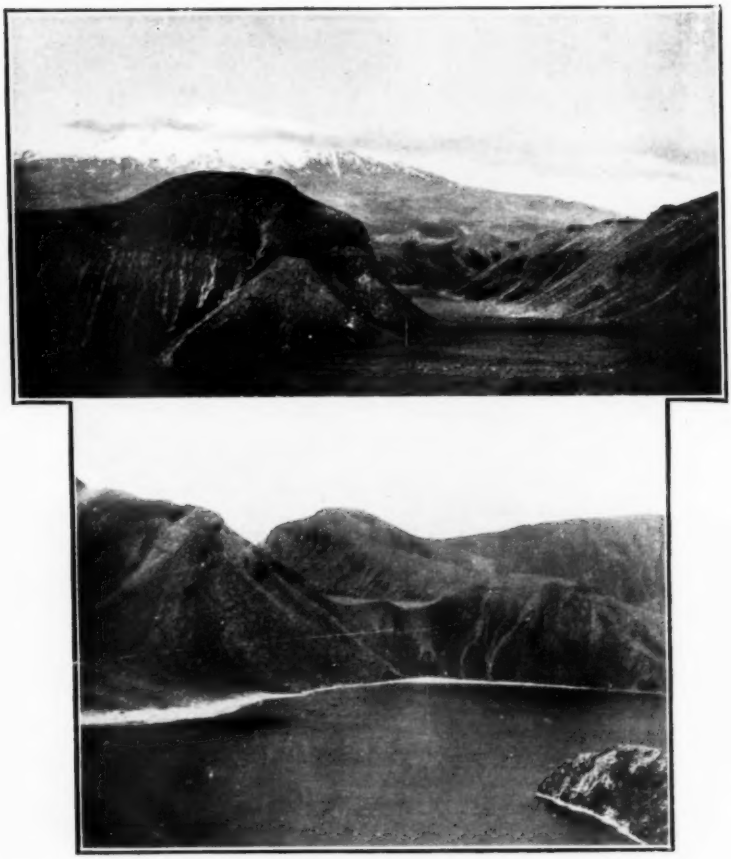
PLATE XIX



(a) THE GREAT RIFT VALLEY.

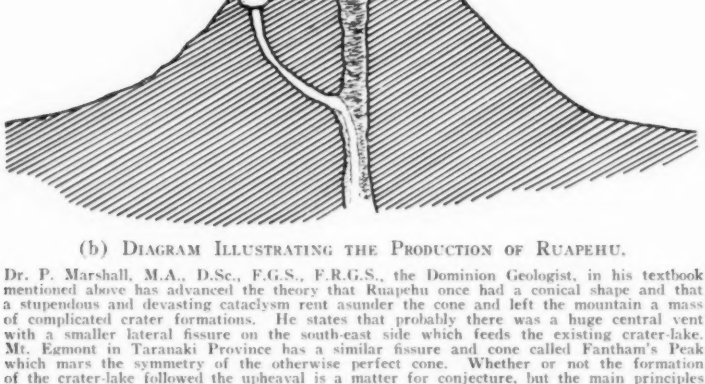
This print shows the precipitous sides of this great chasm described in the text. The slopes seen at the far end of the valley are those of the larger Tama Lake shown in the next illustration. The snow-clad peak in the background is that of Te Heuheu, the northern extremity of Mt. Ruapehu, and is about nine air miles from the scene of the photograph, which was taken about 2,000 feet below the summit of Ngauruhoe and about 2,735 feet above the valley floor. The precipice shown in shadow on the left is the columnar andesitic formation mentioned in the text.—*Photograph by the Author, December 27, 1923.*

(b) THE LARGER OF THE NGAPUNA-A-TAMATEA LAKES.

The southern end of the great Rift Valley can be seen in this photograph where it ends in a 540 feet precipice. The pumice beaches mentioned in the text are shown at the left. The desolate appearance is well shown.—*Photograph by the Author, December 23, 1923.*

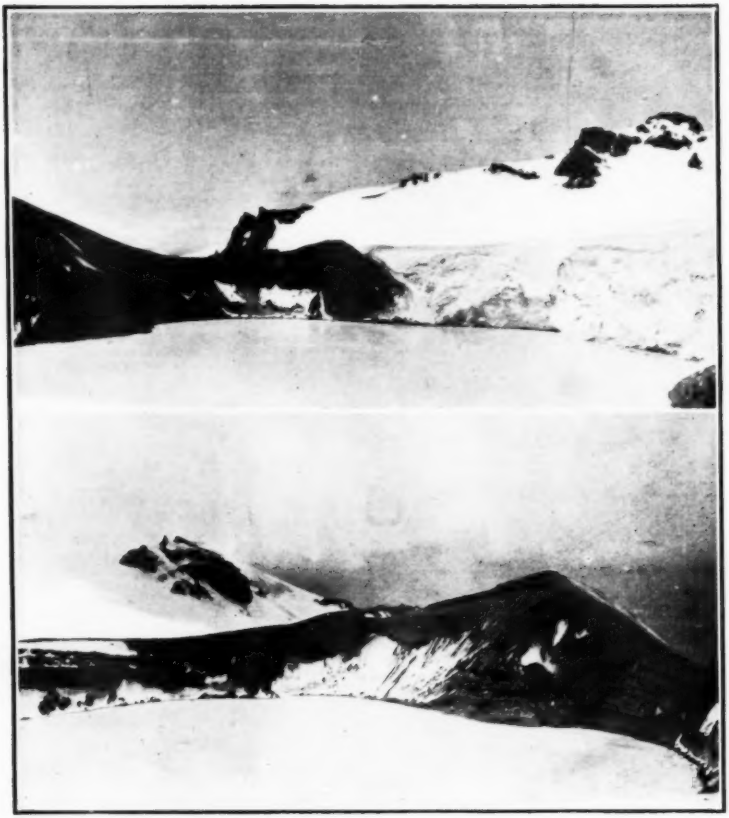
(a) THE SMALLER OF THE NGAPUNA-A-TAMATEA LAKES AND RUAPEHU.

This view shows the cup-like appearance of this explosion crater, and it is interesting to note that Mr. Henry Hill, B.A., F.G.S., has observed great deposits of heavy boulder-like pumice along the northern slopes of Te Heuheu peak in the background, which seem to have been ejected by these lakes, as the line was traceable from them in a kind of fan in a south-easterly direction. The Nga Tohu or Pinnacle Ridge mentioned in the text shows in profile at the right against the Whakapapa Glacier and the Crater lake is behind the right end of the ridge and just to the immediate left of Pare-te-tai-Tonga peak in the far distance. The bleak appearance of the country on the left is well shown, and just out of the picture to the right is the main watershed of the North Island.—*Photograph by the Author, December 23, 1923.*



(b) DIAGRAM ILLUSTRATING THE PRODUCTION OF RUAPEHU.

Dr. P. Marshall, M.A., D.Sc., F.G.S., F.R.G.S., the Dominion Geologist, in his textbook mentioned above has advanced the theory that Ruapehu once had a conical shape and that a stupendous and devasting cataclysm rent asunder the cone and left the mountain a mass of complicated crater formations. He states that probably there was a huge central vent with a smaller lateral fissure on the south-east side which feeds the existing crater-lake. Mt. Egmont in Taranaki Province has a similar fissure and cone called Fantham's Peak which mars the symmetry of the otherwise perfect cone. Whether or not the formation of the crater-lake followed the upheaval is a matter for conjecture, but the main principles of Dr. Marshall's theory are (in their essentials) supported by Mr. Henry Hill and Dr. Friedlander. The outlet of the large vent is in all probability hidden by the glaciers and snowfields of the mountain-top.—*From "The Geography of New Zealand" by kind permission of Dr. Marshall.*

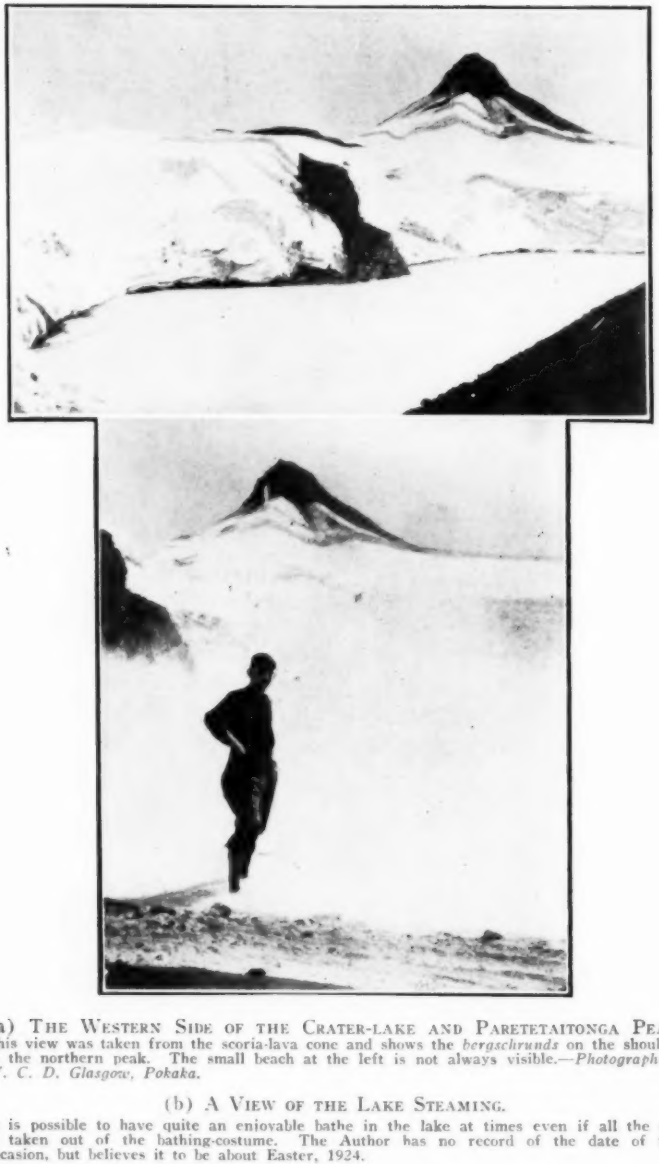


(a) THE CRATER-LAKE ON MT. RUAPEHU.

This view was taken from near the northern ice-cliffs and shows the summit of Ruapehu in the background. This peak is the highest in the North Island. Portion of the scoria and lava cone mentioned in the text is seen at the left, and it is down the boundary between the ice-field and the scoria in the centre of the view, that the only route to the water's edge, lies. A few minutes after this photograph was taken, the overhanging ice-cliff broke off, and visibly diminished in size after contact with the warm lake. The clouds just seen completely hid the surrounding countryside.—*Photograph by the Author, January* 1, 1924.

(b) THE CRATER-LAKE ON MT. RUAPEHU.

This view was taken from the summit at an elevation of 975 feet above the lake, during a momentary lifting of the cloud which hides the northern portion of the mountain-top beyond the Cathedral Rocks which are just visible. The full extent of the scoria-lava cone on the eastern side is seen here, with the alternate layers plainly indicated. It is from under the Whangahu Glacier behind this cone that the Whangaehu River rises at an elevation of about 7,000 feet, and reliable observers state that there is no doubt that this stream is the only known overflow of the lake. The peculiar streaks on the water are seen to the left. Unfortunately, the beautiful colouring of this scene cannot be reproduced, the cone being reds, browns and blacks, with a few sulphur streaks on the blue-green ice-cliffs.—*Photograph by the Author, January* 1, 1924.



(a) THE WESTERN SIDE OF THE CRATER-LAKE AND PARETETAITONGA PEAK. This view was taken from the scoria-lava cone and shows the *bergschrunds* on the shoulder of the northern peak. The small beach at the left is not always visible.—*Photograph by W. C. D. Glasgow, Pokaka.*

(b) A VIEW OF THE LAKE STEAMING.

It is possible to have quite an enjovable bathe in the lake at times even if all the dye is taken out of the bathing-costume. The Author has no record of the date of this occasion, but believes it to be about Easter, 1924.

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THE RUAPEHU CRATER LAKE

A LITTLE-KNOWN THERMAL PHENOMENON IN THE TONGARIRO NATIONAL PARK, NEW ZEALAND

By JAMES W. ALEXANDRE

(With Plates XIX-XXII)

INTRODUCTION

ALL seismologists and volcanologists will be familiar with the fact that it is in the bed of the Pacific ocean and its borders that most of the recorded volcanic activities originate. This is due to the presence therein of three great faults or lines of weakness in the crust of the earth. That on the eastern side first shows itself in the thermal activities of the famous Yellowstone Park, a small lateral of this fault being responsible for Mt. Lassen in California. The next sign of volcanic disturbance is to be seen in the mighty peaks, Orizaba and Popocatepetl in lower Mexico. From here the line of weakness runs through the innumerable active volcanoes in Nicaragua, Honduras and the other Central American countries, down to Cotopaxi, Sangay, Orsono and others in the Andean range in and about Ecuador. There are apparently no other outbreaks south of this latter group, so we may then proceed to consider the great western fault which commences in or near the Valley of the Ten Thousand Smokes, and Mt. Katmai in the Alaskan Territory. Numerous volcanoes in the Aleutian Islands continue the fault across the Behring Sea to the Kurile Islands and down to Japan with Fujiyama and its hydro-thermal phenomena

that has such a remarkable similarity to New Zealand's. The line of weakness continues down past Formosa, Borneo and the Sulu Sea, and the Straits of Sunda and the hotbed of volcanoes in the Javan group. This chain has several laterals that do not concern the subject of this article. The great trans-Oceanic fault-line that is directly responsible for the New Zealand Thermal Zone starts in Alaska and passes through the Hawaiian Islands, famous for the great Kilauea Fire-pit and Mauna Loa. The next outburst of the hidden fires occurs in Savaii, and is again found in the earthquake-troubled Tongan archipelago wherein are some two dozen or so active volcanoes, some five or six being submarine, notably the famous Jack-in-the-Box of the Pacific, Falcon Island. Further south the Friendly Islands have an active region and the fault-line does not again become evident until the Kermadec Islands are reached, where there is a quiescent volcano on Sunday Island, and old craters and hot springs on Curtis and Macauley Islands. The great crust-crack then reappears at the Bay of Plenty on the north-east coast of the North Island of New Zealand. Here the viciously violent solfatara volcano of Whakaari or White Island, as it is commonly called, is to be seen. The fault-line continues through the wonderful Thermal Zone of Rotorua and Taupo to the active chain of volcanoes, Tongariro, Ngauruhoe and Ruapehu. It leaves the southwest coast of the north island and does not reappear until the Antarctic is reached, where the semiactive Mounts Erebus and Terror are alone in their snowclad majesty.

A Short Outline of the Thermal Zone

This wonderful area is most remarkable for the almost incredible variety of the volcanic and hydro-thermal phenomena found therein, and it begins in the peculiar solfatara volcano White Island, in the Bay of Plenty. A fertilizer company exercises certain rights over this island, but the procuring of the raw sulphur rock is a precarious business, as some years before the war the island was violently active and it is surmised that the disturbance was responsible for an enormous collapse of the crater walls upon the works. The whole establishment disappeared and the sole survivor that was found by an anxious search-party was the poor starved cook-

house cat wandering disconsolately over the landslip, where there was not enough timber from the works left to make a matchbox. The industry still carries on in a spasmodic manner, however, when the subterranean activities permit it. The next large sign of a thin earth-crust is to be found in the Rotorua Geyserland, amongst the wonders of this being the Fairy Spring, where the water is so clear that the innumerable trout in it appear to be swimming in air. There are geysers, hot mud-pools that have great curative properties supposed to be due to the presence of radio-active substances, hot pools, one of which in the Ohinemutu Native Reserve being called the Lobster pool. Any swimmer that ventures into this large pool has a nice warm swim, but upon emerging he finds that he is stained a choice copper tint that takes a long time to wear off. A peculiar feature of this district is that the pipes all have to be renewed very frequently on account of the silica blocking them; also residents are not allowed to dig holes of more than three feet deep or thereabouts on account of the risk of starting something they can't stop. After the traveller leaves the principal geyser district of Whakarewarewa in Rotorua, he proceeds to Wairoa, the buried village, passing en route the blue-lake Tikitapu and the green-lake Rotokakahi, these being separated by a narrow neck of land. They are remarkable for the vivid colouring. Wairoa native village was overwhelmed in 1886 by the eruption of Mount Tarawera, which was responsible for the destruction of the famous pink and white terraces, the formation of an enormous rift on the mountain, and the enlargement of lakes Tarawera and Rotomahana, which has steaming sides and water in places too hot to place the hand in. The world's greatest mud-volcano-geyser Waimangu is in this district, being only seventeen miles from Rotorua. It has been responsible for two tragedies, the first being many years ago when a party of three tourists wilfully and foolhardily ventured onto specifically forbidden ground at the brink of the cauldron. The geyser blew up all over them. The latter tragedy was very sad. The great pit had been regarded as dead for many years, a species of swamp reed (raupo) growing on the bottom. There was a caretaker's residence well away from the crater but overlooking it, and one day a few years ago, while Mr. Warbrick was in Rotorua, the geyser erupted, throwing out boiling mud and incandescent

boulders which overwhelmed the house and set it alight. Poor Mrs. Warbrick wrapped most of the clothing she had on about her baby and set out on a nightmare struggle through the hellish hail toward Rotorua. The poor fugitive eventually reached an outlying farmer's residence whence she was conveyed to the Rotorua hospital, where she died as the result of her burns, most of her clothing being burned off. She gave her life for her baby as the thorough wrapping-up it got saved it. In its peak activity the geyser often ejected water, steam, mud and rocks to a height of 1,500 feet. Since that outburst it appears to be very quiet. After the Tarawera district is left behind, the remarkable geyser valley of Wairakei is reached. It is only about a quarter of a mile long but it is packed with all sorts of weird natural attractions, hot pools within a few inches of a cold stream, champagne cauldrons, mud-volcanoes, geysers and numerous other uncanny sights. There is another peculiar blowhole ar Waiotapu, some little distance away. Here an enormous steam-jet makes conversation impossible, and the ground tremble. A favourite trick of passing motorists is to throw an empty benzine tin into the outlet, whence it is violently expelled and is thrown about fifty or sixty feet into the air, and it is a sadly spoiled tin, being crumpled like a pocket handkerchief. After leaving this noisy scene, the alum cliffs at Orakei-Korako are seen in all their peculiarly vivid stripes of colour. Soon the traveller arrives at the trout-fishing centre, Lake Taupo, which is the largest lake in the Dominion and is about twenty-five or so miles long. Prominent geologists suppose that it was once a mighty volcanic crater long ago, for no other reason or theory can possibly account for the unfathomable depths of the huge pumice deposits that cover large tracts of lands for miles about the lake. Government afforestation schemes are being successfully carried out on the Kaingaroa plains through which the tourist route from Rotorua passes. Pinus insignis is the tree that takes most kindly to the pumice. The longest and largest river in New Zealand is the Waikato, which has its outlet from near Taupo township on the north end of the lake. In certain places near the township the lake at irregular periods raises and lowers its shores. In the distance across the lake to the south can be seen the large volcanoes of the Tongariro National Park, and after boarding the small steamer or launch the tourist is

brought to Tokaanu, at the south end of the lake at the mouth of the Tongariro river. This little town, like Taupo, is a trout-fisher's paradise. The distance from this township by the motor road to the railway station near the other end of the National Park is some sixty miles. The torn and wrecked Mt. Tongariro, 6,458 feet, is first seen from Tokaanu. Its active crater Te Mari and the medicinal hotsprings near the Ketetahi blowhole are sure to attract interest in the passing traveller. Very close by is our only really active volcanic cone, Jauruhoe, 7,515 feet, with its never-ceasing plume of steam, and sometimes ash-filled steam. Some ten or twelve miles to the south is Mt. Ruapehu, a quiescent volcano, 9,175 feet. It is usually considered extinct, but as history shows, this is a very rash thing to state with any certainty. I shall now give a brief outline of the history of the area, followed by the topographical and geological description of the range, before describing the remarkable natural feature at the head of the article.

The History of the Tongariro National Park

This, by virtue of the necessity of conserving space and of keeping to the point of the recital, must be brief and accordingly I must omit a repetition of the exceedingly interesting Maori legends dealing with the mountains, as legends and folk-lore are not facts, and no doubt the reader will think I am sufficiently long-winded as it is, but I deemed it wise to give an adequate description of the Thermal Zone first of all. The primeval mystery and religious awe with which the ancient Maori regarded these mountains were the cumulative tradition of *tapu* upon *tapu* that clung to the Tongariro group until less than a generation ago, when by the removal of the remains of the greatest of the Heuheu chiefs from their long resting place in a cave on Tongariro's northern flank, the last of the heroic spells against desecration was removed. For the origin of the *tapu* ban we have to seek back many centuries into legends too involved to traverse here. The tradition of Ngatoro-i-Rangi (a famous ancestor of the Ngati-Tuwharetoa Maoris of the Taupo region) with his priestly ceremonies and adventures bring the tale of *tapu* into historic times. Later still there is the association of the great Taupo chiefs with the holy mountain, and their identification of it

with themselves as their *tupuna* or god-like ancestor. Ever since white travellers first found their way into the heart of New Zealand, the *pakeha* or white man was forbidden to violate the *tapu* of Tongariro. It is not known exactly how the vigilance of the native cordon was evaded, but Ngauruhoe was first ascended by J. C. Bidwill in 1839. The scientist Dieffenbach in 1841, E. J. Wakefield in 1842, the artist G. F. Angas in 1844, and Sir George Grey, the Governor at the time in 1850, found themselves within sight of these mountains of desire but were unable to climb them. Sir George Grey was not actually forbidden to ascend the peaks, but he found it prudent not to insist on the expedition. A Mr. Dyson broke through the native outposts and ascended Ngauruhoe in 1851 and thereby greatly angered old Iwikau Te Heuheu. Baron von Hochstetter, the geologist, was also forbidden in 1859, and it was not until 1879 that Messrs. Beetham and Maxwell succeeded in ascending to the crater of Ruapehu. Around about this time the country was trying to get over the war years, and many of the tribes were still very nervous and touchy, and it was only with the very greatest difficulty in the face of exceedingly determined native opposition that Messrs. Cussen and Sims completed the trigonometrical survey in the mountains in March, 1883. In March, 1886, a sitting of the Native Land Court was being held in Taupo for the purpose of deciding the exact ownership according to native custom of the various blocks of land comprised within the *rohepotae* or general boundary of the territory known as Taupo-nui-a-Tia. It was attended by the paramount chief of the Ngati-Tuwhareota people and many of his subordinate chiefs. The old paramount chief Te Heuheu Tukino (who was known as Horonuku, *i.e.* "Swallowed up by the earth," in memory of his father's tragic death in a landslide) was accompanied by a man whom he had practically been a foster father to, and who was his close friend and adviser, Mr. L. M. Grace, a pioneer white missionary. It was during the discussion of the apportionment and disposal of the mountains Tongariro, Ngauruhoe and Ruapehu that Te Heuheu's protégé, Mr. Grace, noted that his old benefactor was *pouri* or troubled about his *mana* or prestige, which was inextricably connected and involved with the possession of the volcanoes. If the peaks were to be separately owned by outsiders, his *mana* would be gone

amongst his own people, and Mr. Grace was able to persuade his friend to "save his face" by giving the mountains to the Crown "for a public park for ever," and on the 23rd September, 1887, the negotiations were finalised in a deed between Te Heuheu Tukino, "aboriginal native chief of the Colony of New Zealand" and Her Majesty Queen Victoria.

From time to time the land has been purchased in order to enlarge the park, and in 1926 the area was 149,470 acres. The boundaries of the park are approximately as follows : it extends over an area of about twenty-five miles roughly north and south, and nineteen miles in greatest breadth east and west, and is somewhat irregular in shape. The whole region is remarkably easy of access; the summit of Ruapehu is only a dozen air miles from the main trunk railway, and is about 210 miles by rail from Auckland. The National Park is encircled by motor roads and it is hoped some day to lay out an aerodrome near the Chateau Tongariro at the base of Ruapehu.

The Topography of the National Park

The physical layout of the mountain area can be best understood if a beginning is made at the north end. After leaving Tokaanu, the land rises rapidly into a large plateau, which, not counting the mountains themselves, varies in height from 1,500 feet to 4,000 feet above sea-level. The highest part of the tableland is the area between the northern base of Ruapehu and Ngauruhoe volcano, where the land rises ruggedly to about 5,000 feet and is dissected with the heads of watercourses and pitted with explosion craters, chief of which are the Ngapuna-a-Tamatea or Lakes of Tamatea, which are shown in Plate XIX, *a* and *b*, and which will be described later. This height of land is the watershed of the Waikato river on the east and the Whanganui river on the west. On the southeast of the plateau is a desert, to be described later; here the vegetation is very sparse and the aspect is bare and desolate and windswept. In other parts the plant-covering is greatly varied and often very rich, with flowering plants of great beauty. Putting it briefly, as it does not concern the main subject, the National Park is a botanist's paradise. After leaving Lake Roto Aira at the

lower northern slopes of Tongariro, the climber bent upon exploring the torn and scarred ruin of a mountain encounters a small belt of sub-alpine Totara forest, and then ascends to the Ketetahi blow-hole with its attendant hot springs, renowned for their curative properties. Comparatively near is the active Te Mari crater, 5,641 feet. The whole Tongariro mountain presents a scene of appalling desolation as the entire area is seamed and pitted with craters, which at some remote age must have blown the top off in a stupendous cataclysm. There is a large apline meadow about two miles long on the mountain top, but otherwise it is one series of craters, the largest of which are :—North crater 6,100 feet, West crater 5,530 feet, the Blue lake crater 5,570 feet, with its lovely lake called in the many syllabled native tongue, Te Wai-whakaata-o-Te Rangi-hiroa (the Mirror of Rangihiroa), the Central crater 5,540 feet with the vari-coloured Roto Pounamu sulphur lagoons, the active Red crater 6,050 feet, the South crater 5,420 feet, and the low level Oturere crater. There is a low scoria saddle connecting Tongariro with Ngauruhoe, and in the Mangatepopo valley between them are two mountain huts and a soda spring which is only harmful when mixed with too much whisky. The always active cone Ngauruhoe, 7,515 feet, has three craters inside its precipitous outer rim, which on the east side is about 150 feet higher than the west side. The oldest crater forms the principal floor of the volcano and has a few fumaroles and snow fields covered with ejected mud. With a party of six others I descended the craters in the Christmas season of 1923-4, and the climbers had to go down a very dangerous scree slope from a crack in the rim on the highest side. By carefully negotiating a tortuous gut in the old crater-floor we arrived, all roped together, at the brink of the deep crater. It was exceedingly difficult to see the floor of this pit on account of the dreadful yellow acid-laden fumes and steam blowing about us, but the few glimpses I did get of the sides and bottom, showed the floor to be of soft ash with big deposits of sulphur. There were many fumaroles in the bottom, and the various colours visible were very striking. The floor appeared to be moving or heaving slightly and the noise was deafening. After we had a light lunch we climbed out of the crack where we had only kept from sliding in by digging our heels into the ash and lying back on the slope, and descended right into the bottom

of the lesser crater which is not quite so deep and has not the perfectly precipitous sides of its neighbours. Here were many fumaroles and steam jets with a boiling pool of black liquid surrounded with a crust of black and yellow mud which blew out a week after our visit. It was an exciting experience with the thunderous thuddings underneath which made the loose stones jump, and in places the crust was too soft to walk upon. I had an exceedingly unpleasant memento of this day in the shape of a total loss of my voice for about three days, being quite unable to even whisper owing to the manner in which the gases had acted on the larnyx and bronchial tubes. The cone of Ngauruhoe has an average slope of 40 degrees, the steepest batter being on the eastern side, and after an eruption, is exhaustively difficult to ascend on account of the slipperiness and depth of the ash near the upper portion and the loose rocks below. The climber after descending the southern slopes finds himself in a veritable chaotic sea of desolation, explosion craters, lava streams and desert. I spent over fifteen hours on the mountain this day and the only vegetation I saw on its slopes was a pair of small hairy leaves on a tiny root. There is a big spur called Pukekaikiore on the southwestern slopes of the cone and from here there is a rugged valley extending around the southern base to Tongariro. The southern sides of this valley are made up of a tumbled mass of stony hills, and are split by a remarkable explosion chasm, called the Great Rift Valley by Mr. Laurence Cussen, the pioneer surveyor. It is nearly a mile long and is nearly half a mile at its widest, and is shown in Plate XIX *a*. The left-hand precipice is about 496 feet above the valley floor and at its northern end, *i.e.* nearest to the camera, and indicated by the shadow, there are some remarkable forms of columnar andesitic lava which provide plenty of work for that peculiar fraternity known as rock-climbers, there being several fine chimneys with difficult capstones. The photograph was taken about 2,000 feet below the summit of Ngauruhoe and about 2,735 feet above the Rift floor, so the roughness does not become apparent. At the far end of the valley there is a precipitous descent of about 540 feet to the larger Ngapuna-a-Tama lake which is shown in Plate XIX *b*. The southern end of the Rift with the precipice just mentioned can be easily seen. Note the desolation everywhere. This lake is somewhat kidney-shaped and is an

old explosion crater. It is 4,240 feet above sea-level, and is about three-quarters of a mile by just over a quarter of a mile. A tumbled mass of rocky-ridge known as Tama mountain, about 5,190 feet, separates this lake from its smaller mate shown in Plate XX*a*. The steep sides of this explosion crater are well shown, being taken from the overtopping ridge just mentioned. Under suitable atmospheric conditions and the right lighting, the funnel shape is clearly evident and the central pipe can occasionally be seen. There is no record of any soundings of either lake being taken, but the smaller must be very deep from the intensely deep blue colour of its water.

The two lakes have no visible outlet and are frequently frozen over in winter, and the hydrographer desiring to chart their bottoms would have an uncommonly difficult task in taking even a collapsible boat down the steep rocky cliffs and loose scoria slopes that drop abruptly in places to narrow pumice beaches which can be seen in Plates XIX *b*, XX *a*. The sides and margin of the smaller lake shown in Plate XX *a* can be seen to be wooded with pretty flowering shrubs. From these craters it is believed great quantities of pumice were ejected. Mutton-birds have their breeding-places in recesses of the lava cliffs, but as there are no fish in the lakes, it is a mystery what they feed upon. In Plate XX *a* can be seen the pyramidal northern peak of Ruapehu, Te Heuheu, named after the distinguished donor of the park, rising fairly abruptly from a wilderness of red rock and scoria. To its right in the plate can be seen the Nga Tohu or Pinnacle Ridge silhouetted against the Whakapapa glacier. This ridge presents some interesting features, as in places the rock wall looks as if made by hand, as the cracks run vertically and horizontally generally speaking, and one gets the impression that one could pluck out some of the stones, they look so loose. There is a curious bubble cave that sometimes has served as an emergency shelter for stormbound climbers. They have to pack in like sardines. The country to the east or left side on the plate is bare and bleak, windswept and lonely. There are many deep fissures eroded by the rains, marshy shrubby steppe in some places and strange smooth areas with the vegetable sheep plant. The only wild life here is a number of mobs of wild horses descended from a small number liberated many years ago, together with a few

rabbits. On the western side of the divide, as the saddle between Ruapehu and Ngauruhoe is called, and just out of Plate XX*a* the country is very bare, with tussocks and turpentine bush with occasional belts of mountain beech. There is a low sprawling ridge or spur known as the Tama ridge leading westwards from the saddle to the Waimarino plain upon which is to be seen a low isolated extinct volcano Pukeonake, which rises about 1,100 feet above the plain. Barring Ruapehu, the only other eminence is Mt. Hauhungatahi, 4,983 feet. It is a beautifully wooded extinct volcano. Mt. Ruapehu is the highest point in the North Island and the most northerly glaciated alp in New Zealand, its latitude being 39°17′ south. Its contour, especially when viewed from the north, resembles a great crown, sweeping up from the bare desert plateau to a supernal series of glittering ice points. Its isolation from other high alps gives an added dignity and glory to its mighty form, and it is sufficiently far removed from the Tongariro group for its features to be considered without others obtruding themselves on the eye, yet near enough for contrast and comparison with its companion mountains of the National Park. Below the snow-line on the southern and western slopes, the mountain is heavily wooded with red and silver beech, silver pine and mountain cedar. The snow-line ends in shrubby steppe and bogs. The top of Ruapehu is a roughly oval basin which is something over a mile in diameter north and south, filled with ice, and is the great *névé* which feeds the glaciers that hang on the mountain's shoulders. The great eastern wall is broken away by ancient explosions, and lava flowed down in huge volume to the edge of the plain. A feature of the Tawhai tableland on the plain between the Whakapapaiti and Whakapapanui rivers are the three lines of volcanic hummocks called Ngapuke-takutai, that extend parallel with each other from near the base of Ruapehu to near the Whakapapaiti gorge. There are about seventy hummocks, some fairly large, others quite small. They are ancient lava bubbles. There is another large line of hummocks slightly different in nature that commences in the bush at the base of Ruapehu and follows the course of the Tawhai stream to the road where it bends away to the gorge. It is known as Ngapuke-turua, and when within recent years a motor road was cut through this line one hummock was cut into two and it was found

to be formed of scoria and andesitic boulders and several well-known geologists have examined it and the consensus of opinion is that there is no possible doubt that this last-mentioned line of hillocks is the terminal moraine of an immense long-gone glacier that flowed down from the western side of Ruapehu and spread over the Waimarino plain. There is ample evidence in the shape of isolated striated boulders on the lower slopes to support this theory, but space considerations forbid any discussion upon it. Returning to the study of the mountain we find as I have mentioned before, that the northern extremity of the volcano is the splendid spire of Te Heuheu, whose perpetual white is relieved by the black lava ridges of pinnacles and cliffs on its sides. On the west along the curving rim there is a magnificent peak known by the beautiful name of Para-te-tai-Tonga, 9,025 feet. This euphonious name is supposed to be a corruption of "Pari-teitei-Tonga" (the lofty peak to the south). To the observer on the western side it appears like a dog's tooth and by the uninitiated is thought to be the summit, but this is well round to the south and is the real Ruapehu peak, 9,175 feet, although the whole mountain goes by the name Ruapehu, which is generally understood to mean "Resounding pit or hollow," obviously so named from the times when eruptions were more violent. The summit of Ruapehu presents marvellous contrasts of heat and cold. There is the enormous saucer of ice, greatly crevassed and split by huge bergschrunds of unknown depth, and there are the glaciers fed eternally by the central *névé* or by snow fields of their own, and in their turn giving rise to the countless alpine torrents and waterfalls that do so much to beautify the mountain on a hot summer day; and then there is the wonderful crater lake which inspired me to write this article. There only remains now to describe the eastern portion of the park, when I hope the reader will be able to visualize this wonderland. The bare wind-swept tussock plateau on the eastern side of Ruapehu, which is traversed by the Waiouru-Tokaanu main road, is for a large area a true desert, a sterile waste of pumice, sand and stones. What vegetation there is consists of stunted shrubs, tussock, mat and cushion plants. The remains of the ancient forests, destroyed by hot pumice showers, are seen here, and there are the pumice road cuttings and the gullies. Carbonised or charred timber is embedded in these

volcanic sands. The district generally both east of Ruapehu and extending toward the Kaimanawa range is called the Rangipo by the Maoris, a combination of the words for sky and dark, or day and night—meaning the place where the sky was darkened by a violent volcanic eruption. The heart of the Rangipo, the desert region, is Oné-tapu, the Sacred or Enchanted Sands, and is a bleak shivering land ever dreaded and avoided by the Maoris. The legend giving rise to the name is too long to give here. The talented botanist, Dr. Cockayne, in his report on the park, writes thus of the Rangipo desert :—"Situated on the highest part of the plateau, the surface of the ground is exposed to the full force of the wind. The melting snows and rain also cut furrows into the ground, undermining the surface, and exposing the bare ground to the violence of the gales. In consequence, a large area has in course of time become a sandy waste. That this has not been so always, is shown by the curious mounds here and there, covered with grass or shrub steppe, which stand like islands in the sea of sand. All transitions are seen, from such, to low mounds where dead stems and roots alone persist. At its lower portion many acres of the desert are quite without plant life, stretches of sand alone exist, or where this has blown away, there is consolidated pumice or soft rock Here lie scattered the remnants of former shrubs. As Ruapehu is approached, the plant covering becomes denser and denser, the tussock closer and closer until finally an open grass-steppe results. In some places the surface is covered with numerous small pieces of lava, and in others the surface is all pumice, many pieces large and small lying on the ground. This desert is by no means a feature of to-day. It changes its position from time to time, but at the time of the pioneer missionary Colenso's visit it evidently had exactly the same position as at present."

The Geology of the Volcanic Plateau

Baron von Hochstetter, an Austrian nobleman of very high scientific attainments and a geologist of note, made an exploration of the interior of the North Island in 1859, and he wrote a book which ranks as the best authority on New Zealand geology right up to the present day. He was not able to ascend Tongariro owing

to the Maori prejudice previously referred to, nevertheless he closely studied volcanic phenomena in the Taupo region. On the subject of the sequence of volcanic phenomena in these parts, he wrote that the first volcanic eruptions were submarine, consisting of vast quantities of trachytic lava, breccia, tuff, obsidian, and pumice-stone, which formed an extensive submarine volcanic plateau. The volcanic action continuing, the whole mass was upheaved above the level of the sea, and new phenomena were developed; lofty cones of trachytic and phonolitic lava, of ashes, and cinder were gradually formed. These eruptions breaking through the original submarine layers of trachytic lava, breccia, and tuff, raised them, and left them as we now find them, forming a more or less regular belt round the central cones, and having a slight inclination from the centre outwards.

Of modern geologists, Professor A. P. W. Thomas, Dr. P. Marshall, Dr. J. Allan Thomson, Professor R. Speight and Mr. Henry Hill, B.A., F.G.S., have written a great deal on the structure and history of these volcanoes. Professor Speight, summarising his observations in a report to the government on the geology of the district, says that it is possible that both Ruapehu and Tongariro were originally submarine volcanoes, but this cannot be stated for certain, as their bases are in no place exposed to view. Where contact with the older rocks no doubt exists, a surface accumulation of drift prevents satisfactory examination. It seems reasonable to say, Professor Speight continues, that the foundations of Ruapehu and Tongariro were laid in late Pliocene times—that is, they are geologically very young—and that activity has persisted ever since. During all this time lavas and scoriaceous matter have been erupted, and accumulating around the volcanic vents, have built up the cones. The chemical composition of the lava varies somewhat, and the later flows show a close relationship to basalts. The lavas all contain the mineral hypersthene or its near relative enstatite as a characteristic constituent, though hornblende and augite also occur; the former is rather rare, the latter is extremely common. Dr. J. Allan Thomson (New Zealand *Journal of Science and Technology*, Dec. 1926), in a geological and historical review of the volcanoes of the New Zealand-Tonga zone, describes the linear arrangement of volcanoes from Ruapehu to the active region in the

western seas of the Tongan archipelago. He does not carry the line beyond Tonga, and says that a feature of the volcanoes from Ruapehu to Niuafoou is the dominance of andesitic lavas and ashes in the cones. From this fact and other structural relationships, one is justified in considering the whole system as one volcanic group with common physical conditions governing eruptions and common chemical conditions governing the magmatic similarity. It has been considered that the lava age is a thing of the past in New Zealand volcanoes. Occasionally lava has been reported, but upon skilled investigation, what was seen usually proved to be either burning sulphur or rocks in an incandescent but not liquid state. In 1910, Dr. P. Marshall, now the Dominion Geologist, accompanied by Mr. E. Phillips Turner, F.R.G.S., lately Director of Forestry, observed lava in the crater of Ngauruhoe, and it is believed that lava also rose into the crater during the winter eruptions of 1926, but none was discharged, the ejecta consisting of ash and incandescent rock, none of which fell beyond the base of the cone. The only known records of lava flows in New Zealand are the eruptions of Ngauruhoe in 1869 or 1870 and that of the Te Maari crater on Tongariro in 1893. The former is disputed by such reliable observers as Dr. Marshall and Mr. Henry Hill, who observed the latter flow just after its occurrence. Dr. J. Allan Thomson, writing in the journal previously mentioned, states that the best accounts of the explosive eruptions make it quite clear that molten magma ascends to the air, but it is so charged with gases that it explodes before it can rise to overflow the crater. Recorded explosions of Ngauruhoe, in which hot ash and incandescent rock was ejected, occurred in 1839 (Bidwill's account), 1857-69 or '70—July '81—Feb. '92—Feb. to April, 1907—March '09—May and Aug. '13—Nov. '17-'24, and April-May, 1926. "Yet all the larger cones," says Dr. Thomson, "show the presence of lava-flows. Either these are relatively so infrequent that nearly a century can pass without one, or there has been latterly a change in the mode of eruption by which the lava has become more explosive. Such a change might be an increase in the viscosity of the lavas or an increase in the gas content, the former being the more probable. The contrast between the explosive eruptions of the andesitic cones of the New Zealand-Tonga line and the relatively

quiet welling-out of lava of the basalt volcanoes of Samoa and Hawaii is very marked, and will necessitate different methods of vulcanological observations in the New Zealand area from those adopted in Hawaii." It has often been suggested and frequently dogmatically stated in New Zealand, that White Island and Ngauruhoe act as "safety-valves" for the New Zealand volcanic area. Dr. Thomson, in criticising this belief, says it apparently presupposes that there is a continuous mass of molten magma underlying the whole line, and that a relief of pressure at one vent propagates itself hydrostatically along the whole line. "It is very much to be doubted," says Dr. Thomson, "whether there is any such continuous mass of molten magma in depth, although Angenheister (1922) finds, from a study of earthquake-waves originating in the New Hebrides and crossing Tonga to be registered at Apia, that there is evidence of 'shallow underground pockets of residual lava' in the Tongan part of the line. But even if there is a continuous body of lava under the whole line, or three separate but in themselves continuous bodies under the Tongan, Kermadec, and New Zealand sections, the viscosity and gaseous content must vary under each cone in such a manner that anything approaching hydrostatic equilibrium cannot be imagined. Each cone is its own safety-valve, and can be little affected by relief of pressure at another cone at any great distance. The coincidence of activity at more than one cone must be ascribed to general conditions, such, *e.g.*, as earth tides, affecting the whole line, and such general conditions, or at least some of them, would also affect other volcanic groups such as the Hawaiian." Discussing the various theories of geologists as to the origin of andesitic magmas such as those of our volcanoes, Dr. Thomson concludes that probably under the upfolding arcs of the earth crust there is a melting both of shales and other continental rocks and of basalt and an admixture, resulting in an andesitic magma.

The Topography of the Mountain Top and the Present Crater

The customary route traversed by climbers on the western side starts at the Chateau Tongariro on the flat ground at Whakapapa,

and after about a mile of mountain beech emerges on the side of the Waipuna Gorge, at the limit of the timber-line. The well-defined track then passes over an expanse of subalpine scrub which gives way to snow-grass steppe, and it is at occasional intervals along this path that one comes across the peculiar blocks of striated stone left by the old glacier mentioned in the section on the Park topography, one of which is known as "The Breakfast Table." The path ends in a desert of scoria and lava known as "The Scoria Flat." "Flat" is a flattering term as will be understood when I state that it is the site of the winter sports activities of the Ruapehu Ski Club. It is very broken country and is limited on the northern side by an odd-shaped ridge Te Herenga, which looks like the hull of an upturned boat. At about 6,000 feet altitude the Ski Club have built two huts for the convenience of the members, and close by is the precipitous cliff known as Skipper's Chimney, which drops sheer into the Whakapapanui Gorge between Te Herenga and the Pinnacle Ridge mentioned before. From this point the going is very rough and steep, although no mountaineering skill is needed, only care. The route then goes through a gorge of short extent and ends at the foot of the Whakapapa glacier. In my opinion this is a misnomer as the area is only an extensive sloping snowfield, there being no crevasses or hard ice visible. From this point the journey is a long, slow tiring trudge, but is not beyond the strength of a sturdy child as some seven-year-olds did the trip while I was there. The longest portion of the mountain-top is not ascended to reach the lake. The mountain-top is really in two portions, the larger and northern being a roughly oval and fairly level snowfield about a mile long north and south, having Te Heuheu peak at the north and the crater lake at the south end. In 1897, Dr. Friedlander, of Berlin, visited the mountain and after extensive examination, gave in a paper in the *Transactions of the New Zealand Institute*, 1898, his opinions, which are in brief, as follows:—What is considered to be the crater of Ruapehu is possibly in truth two adjoining craters, the larger being the big snowfield just mentioned and the other the present crater. The snow drainage of the larger portion takes place through large gaps in the rim in the shape of the Mangatoetoenui, Wahianoa, Whakapapa, Whangaehu and several small glaciers. He states that the southern portion of the main crater

(or if there be originally two, the south crater) contains a secondary cinder cone situated eccentrically on the eastern side, which I shall describe in detail later. He also thinks that this cinder cone is active as a solfatara, emitting hot water, steam and sulphuretted hydrogen, and that the lake is the result of the conflict of the steam and ice, the temperature depending upon the amount and heat of steam on the one side and the amount and rate of *névé* movement towards it on the other side. He further states that in his opinion, the activity of Ruapehu is masked to some extent by the lake acting as a condenser. Dr. P. Marshall, the Government Geologist, in his school text-book, "The Geography of New Zealand," advances the interesting and thoroughly sound theory that the larger snowfield and the northern glaciers are disguising the probable presence of a mighty crater with smaller companion craters formed by a stupendous cataclysm similar to that which caused the multiplicity of craters on Tongariro, and he assumes that Ruapehu once had the shape of a perfect cone like Ngauruhoe, Egmont or Fujiyama, and that the present crater-lake is the result of a small channel opening up between the strata and emerging on the southern side and forming a subsidiary cone similar to Fantham's Peak on Mt. Egmont, 87 miles away in Taranaki. The presumed explosion may have succeeded the formation of the smaller crater and thus deformed it to its present somewhat irregular contour. This theory is supported by Dr. Friedlander and Mr. Hill and is illustrated in Plate XX *b*. If it were possible to lower the level of Ruapehu to that of Tongariro so that the snowfields and glaciers would disappear, it would probably be obvious that the Whakapapa glacier on the western side fills a colossal gap in the rim through which the lava flowed to form the present Scoria Flat after the great explosion. The head of the Whakapapa glacier ends in a level *col* between the Cathedral Rocks at the southern end of the big *névé* just above the lake and Paretetaitonga peak. The smaller or present crater now comes under our inspection. The basin, not considering the lake itself, is somewhere about a mile in diameter, which is hard to judge from the heights of the peaks surrounding it. It is somewhat offset from the north and south line of the main crater, and is to the southeast. Commencing on the slopes of Paretetaitonga near the Whakapapa *col*, we find that the ice

slopes very steeply towards the cliffs bordering the lake, and is deeply crevassed and seamed with huge *bergschrunds*. The ice cliffs, which vary considerably in height according to the seasons, are on the average from 200 to 150 feet high. Between the Paretetaitonga peak and the Patautau-o-Te Rangi ridge there is a low *col* through which some of the surplus ice and snow escaped to form the Mangaturuturu glacier, from whose foot flows the Mangaturuturu stream, frequently misnamed the Sulphur Stream. Mr. T. A. Blyth of Ohakune, a veteran Ruapehu climber of over twenty years' experience, assures me that he has very thoroughly examined the five springs that form this stream, and has only found the northernmost branch to be very slightly impregnated with sulphur. To digress slightly, it is curious how odd finds are made at high altitudes. Many years ago Mr. Girdlestone, a pioneer surveyor of the Park, found a dead horse in Ngauruhoe crater, evidently driven there by wild dogs. Mr. Henry Hill found on the summit of Paretetaitonga the almost perfectly preserved skin and skeleton of a rat. What on earth drove the creature over those glaciers is a mystery. My find was a swarm of dead grasshoppers and blowflies or bluebottles on the Patautau-o-Te Rangi ridge, which are more easily explained, having evidently been blown there by the gales. Returning to the text, this ridge and the main south peak Ruapehu are very steep on the outer sides, and on the inner side drop quite precipitously to the southern icefield bordering the lake. This icefield, like the one on the sides of Paretetaitonga is deeply crevassed in crescent formation. The heat of the lake water undermines the ice-cliffs in caves which are well shown in the succeeding plates, and the huge blocks being top-heavy, break off and fall in. In Plate XXI *a* the cave at the water-level is well marked and the overhanging cliff at the left broke off with a deafening splitting crack and toppled into the water, causing a terrific splash just a few minutes after I had taken the photograph. The eastern side of the lake is totally different to the other portions of the circumference as will be seen by reference to Plate XXI *a* and *b*, where we see a peculiar cone of many-coloured alternating layers of permeable scoria and solid lava. It is down the boundary of the southern icefield and the scoria cone that the only possible route to the water lies, and even then it is only at intervals that descent

is practicable on account of the loose scoria and the rotten *seracs* or ice-pinnacles. The lake itself is a remarkable feature and is variously estimated as being from 200 yards to a quarter of a mile in diameter, but this is, I believe, fairly excessive, being probably about 250 yards the longest way, although it increases in a hot summer on account of the melting of the ice. However, this increase is really negligible. I have made extensive search in various quarters and cannot find any record of soundings being taken. This would be a very risky, dangerous and difficult operation, as the lake is often very hot, and while it is possible to bathe at the eastern side one cannot tell what fumes there would be in the middle. Not only that, there is the difficulty of taking a suitable raft or boat to the crater and launching it. Mr. Russell, in 1881, described the lake as "of the colour of very dirty soapsuds, and was covered with steam wreaths, which made it difficult to say whether the water was in motion or simmering." Mr. Henry Hill observed the lake very carefully in 1889 and described the colour as soapy or greyish-yellow, covered over in parts with a sort of scum which now and again showed an iridescence similar to that of oil on water, and peculiar ripple lines and scum-like bands could be seen spreading themselves over the entire surface of the lake. There appeared to be regular pulsations in the lake, and at intervals of from two to three minutes steam was given off, so that the surface of the lake was hidden for a few seconds. After every pulsation and explosion of steam, Mr. Hill noted cavern-like recesses below the ice-wall on the west side of the lake, as if the waters had subsided somewhat, but these slowly disappeared as the maximum of activity in the movement of the water approached, the hot water seeming to reach the ice-wall about the same moment the steam was thrown off the surface of the lake.

My own observations of the lake's appearance during the New Year of 1924 are very similar to Mr. Hill's, but to use an Irishism, are really quite different, as they are not so spectacular. I saw the colour of the lake to be a dirty mustard tint with sulphur streaks on the ice-cliffs. Except for a few occasional indistinct wisps of vapour, I did not see any steam given off nor did any pulsations appear. The ripple-marks and iridescent scum that Mr. Hill saw were somewhat changed in appearance, the water looking just like

pea-soup that has remained in a vessel without disturbance for some time, *i.e.*, there was a clear layer of liquid at the surface while underneath was a cloudy mass of matter in suspension. This cloudy underlayer was split by dark lanes or rifts which are shown at the left in Plate XXI *b*. I arrived at the brink of the lake at 9 a.m., and after having nearly circled it left it about 4 p.m., and in the interval these dark markings had spread across the lake from the northwest side to the south side, the movement being so slow as to only be noticeable after this lapse of about seven hours. There was a slight smell of sulphur in the air, less than that at Rotorua and almost negligible compared to the awful fumes in the crater of Ngauruhoe a week before. A beautiful sight at this time when I was on the summit, was Mt. Egmont 8,260 feet, pushing its lovely snowy cone crest through the cloud-layers 87 miles away in Taranaki.

Early Eruptions and Surface Changes

For many years the National Park was almost totally unknown to the general public owing to the fact that the North Island Main Trunk Railway did not penetrate the centre of the island until the early part of this century, and up till then the only method of approach was from Rotorua across Lake Taupo to Tokaanu. Thus the only visitors to this district were occasional surveyors or geologists and it will readily be understood that the early accounts of the volcano's activity are necessarily somewhat disconnected and sketchy, but I hope that the accounts given below will sufficiently connect to give the reader an accurate chronology of the volcano's vagaries.

1869.—The first record of any observation of the activities of Ruapehu was made by Mr. Battley, who was engaged in sheep and cattle droving to the troops in pursuit of the guerilla leader, Te Kooti, in 1869. On one of these risky expeditions across the Rangipo plains he saw steam rising in strong volume from the top of Ruapehu at about the centre of the peak, and this fact is of interest in the light of the hitherto-accepted belief that Ruapehu's first indication of volcanic heat was in 1881.

1879.—So far as is known, February, 1879, was the date upon which the crater-lake was first seen by man, when Messrs. Maxwell

and Beetham succeeded in climbing to the main crater basin, from which they looked down upon the lake. They did not approach it or make any report upon its condition. These climbers remarked upon a peculiar feature of the dwarf-forest growth on the flanks of the mountain. The moraines of the ancient glaciers below the present limits of perpetual snow are composed mostly of huge blocks of lava, and the trunks of the dwarf beech crawl along amongst the surfaces of the lava blocks, their branches only being vertical. It is interesting to know that amongst the remaining vestiges of Dartmoor oak forest in Devonshire, the oak trees growing amongst granite boulders of rock formerly presented the same peculiarity of horizontal creeping trunks with vertical branches springing therefrom.

1881.—The first report of the warmth of the crater-lake was made in March, 1881, when Messrs. Russell and Birch and Mrs. Birch saw steam arising from the lake's surface.

1882 and 1885.—Mr. C. E. Field, C.E., twice climbed the range in 1882 and 1885 and saw no appearance of warmth in the lake.

1886.—In January, 1886, Mr. Park, F.G.S., reported that the lake was covered with ice, while four months later on the 16th April, the surveyor, Mr. L. Cussen, observed a violent boiling of the lake, which he saw to be still more active during the Tarawera eruption in the following June. It was presently realised that the crater-lake was really a great intermittent geyser, the greatest in the world.

1887.—Mr. Henry Hill noted that in May, 1887, the lake was boiling hard.

1889.—Mr. L. Cussen, while surveying in the Kaimanawa range, saw immense clouds of steam from the crater on the 1st May, 1889, which was the same day on which Mr. Hill again reported violent agitation of the lake. In the following August it was sufficiently active to eject its waters, the result being a sudden flood in the Whangaehu river. When Mr. Hill climbed up to the crater some months later, he saw that the water from the lake must have welled over the lip of the crater, as the mark of its rise was left on the snow in exactly the same way that the waves of the sea leaves ripple marks on the sands, and mud and boulders of blue clay were scattered over the ice and snow; this last ejecta resembled the

blue clay thrown out at Lake Rotomahana during the Tarawera eruption in June, 1886.

1890.—Mr. Ross, of the Terraces Hotel, states that in March, 1890, he witnessed an eruption from the crater of successive puffs of steam which reached an altitude of over 7,000 feet. There is evidence of former outflows from the lake (see previous year), but nothing of such unprecedented violence or importance could have been anticipated. The contents of the lake were discharged at this eruption in rapid streams pouring down the mountain side and flooding the Whangaehu river and discolouring the Whanganu river. After all the water had been discharged, the steam escaped with a thunderous roar, and a large quantity of volcanic dust was expelled and distributed over the country in fine showers. Mr. Hill witnessed fierce activity in the lake just prior to this outbreak.

1894.—Mr. Dunnage, while in charge of a survey party, ascended to the lake in Easter, 1894, and found it to be a beautiful green colour and apparently cold.

1895.—Mr. Josiah Martin, while staying at Taupo, observed on the 10th March, 1895, a violent eruption of the crater-lake. On the night of Saturday the 9th, deep rumblings were heard, and on the Sunday morning a terrible roar accompanied by continuous earthquakes was the preliminary to the ascent from the crater of a magnificent cloud which rose in the clear calm air to 6,000 feet above the summit. Mr. Martin said that, seen from Taupo, the shaft of gases seemed to be composed of ascending rolling clouds which kept moving upwards steadily and apparently dissolving into the cooler upper air. Then the centre of the shaft became darker and denser and it was evident that a geyser eruption upon a scale of unparalleled magnificence was proceeding. A few hours later the lofty column was headed by a spreading cloud which opened out on either side in midair fully 6,000 feet high. The scene at sunset was one of most sublime and transcendent beauty as the setting sun's rays illuminated the glorious spectacle of the rising wind beating down the column to half its original height, and at about an hour after sunset the drift of a shower was distinctly seen falling from the over-arching cloud. The Whangaehu and Whanganui rivers were heavily flooded and greatly discoloured after this outburst. The next month Mr. Dunnage succeeded, at

very great risk, in descending to the water's edge on the 5th April. He reported that the lake was of a milky colour and boiling violently, and that amongst the talus and ice-blocks at the water's edge there was a deafening roaring noise accompanied by violent sputtering jets of sulphurous steam. At the cost of some painful scalds he was able to find that the water's edge temperature was 128 degrees Fahr. From the northern cliffs he attempted to take a sample of the water, but owing to the crevasses was unable to get close to the brink, and was thus unable to prevent the bottle from spilling as it bumped against the cliff, and in an attempt to free the bottle where it had jammed in a crevice the cord broke.

1897.—Two years later Dr. Friedlander found steam in fair quantity arising from the lake on the 4th April, 1897.

(A painstaking search among all available literature relating to the volcanic region failed to produce evidence of activity in the lake from 1897 up to 1910, and if there are any records they can only exist in private diaries, which are inaccessible to the author, who, however, was fortunate in being able to obtain some brief observations of recent years from Mr. T. A. Blyth of Ohakune, which are given below.)

1910.—Relying on his memory alone, Mr. Blyth informed me that he had never seen the lake boiling to any extent, but in 1910 he remembers seeing bubbles rising in an area of about two square poles near the eastern shore of the crater-lake.

1922.—In January, 1922, Mr. Blyth found that the lake was very warm but not too warm to swim in.

1924.—I observed the lake on New Year Day, and, as I have already described in detail, only saw a few frail wreaths of steam occasionally.

1926.—An unnamed party of climbers reported that the lake was frozen over in August. With respect to this and Mr. Park's observation of January, 1886, Mr. Blyth contents himself with saying that in twenty years of climbing of Ruapehu he has never seen this condition, but he qualifies his remarks by saying that he has never ascended to the crater in August when the snow is at its

maximum depth in the crater, as climbing is exceedingly dangerous at this time of the year.

1928.—On Easter Monday, 1928, Mr. Blyth found the water to be icy cold.

1930.—The temperature of the lake water in February and March, 1930, was such as to prove very enjoyable to Mr. Blyth for a bathe, being lukewarm. He remarks that these conditions are only to be found near the scoria cone on the eastern side, the water near the ice-cliffs naturally being considerably colder.

1931.—In January of this current year, Mr. Blyth found the lake water to be colder than a year previous.

The Crater-lake Overflow

In Plate XXI *b* there is a cone of scoria and lava on the eastern side of the lake, and it is from a low col between this cone and the Cathedral Rocks to its left that the small Whangaehu glacier is fed by the central snowfield. In January, 1929, Mr. T. A. Blyth traced the Whangaehu stream to its main source in a ravine near this glacier at an altitude of 7,000 feet. He states that the stream issues from the rock as a big body of very yellowish milky coloured water about as big as his body. It smells very strongly of sulphuretted hydrogen and he is quite sure that the water has percolated 1,200 feet through the scoria cone from the crater-lake, whose surface is 8,200 feet above sea-level, and that the melting of this tiny glacier would not produce such a big flow of water. The main source is so strongly charged with sulphates of iron and alumina as to taint the river from its source for 70 miles to the sea, while the second and very small source is clear but so impregnated with alum as to be undrinkable. In 1858, a party of young survey cadets were crossing the Rangipo desert, through which the river runs, and they had sufficient courage to taste the milky water and found it to be a conbination of the flavours of rusty iron, alum and zinc. The gas content is soon dissipated into the air and feeder streams do much to dilute the characteristic colour and flavour.

. . .

In closing this paper I have very much pleasure in acknowledging the assistance rendered by the Chairman and Secretary of the

Tongariro National Park Board and Mr. T. A. Blyth (a resident member of the Board) for information received, Mr. W. C. D. Glasgow of Pokaka for photographs, and Dr. P. Marshall, the Government Geologist, for permission to quote from his textbook.

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8 Ashton Road, Mt. Eden,
Auckland, New Zealand.

POPULAR ARTICLES ON ASTRONOMY FOR THE PRESS

By W. E. Harper

ON page 466 of Volume 24 of this Journal were printed the titles of the first 26 astronomical articles appearing in the syndicate of newspapers controlled by the Southam Publishing Company. The titles of 24 more, with the authors, are now given. This makes a total of 50 short articles which have been rather widely read across Canada and which have been favourably commented upon. The present writer, who acted as editor for the series, usually arranged for an illustration where such did not accompany the article, the whole aim being to attract the general newspaper reader and spread abroad an elementary, yet withal an up-to-the-minute, knowledge of astronomy.

We have the assurance of the Company that the quality of the articles has been quite satisfactory but that pressure for space and general business conditions make it desirable to discontinue them for a while at least.

The total monies accruing from the venture, $1,357.50, go to the General Treasury of our Society. A committee is now considering if some small investigation cannot be undertaken in which many of our amateur members across Canada might participate and for which these monies might be rightfully used.

Schedule of Newspaper Articles

(Continued from Vol. 24, p. 466)

27	1930, Nov.	1	S. N. Hill	Mars
28		15	W. M. Tobey	Elevations and Distances
29		29	A. H. Miller	Gravity Determinations
30		Dec. 13	F. T. Stanford	Seeing Things at Night
31		27	J. Patterson	The Weather
32	1931, Jan.	10	R. J. McDiarmid	Eclipsing Variables
33		24	R. O. Redman	Opposition of Eros

34	Feb. 7	F. N. Denison	Weather Cycles
35	21	C. A. Chant	The Great New Observatory of Canada
36	Mar. 7	W. E. W. Jackson	The Compass
37	21	L. A. H. Warren	The Moon
38	Apr. 4	W. S. McLenahan	Time
39	18	C. S. Beals	Astrology
40	May 2	A. Vibert Douglas	The Pole Star
41	16	W. E. Harper	Collisions Between Stars
42	30	J. S. Plaskett	Gaseous Matter in Space
43	June 13	R. K. Young	Large Velocities in the Universe
44	27	W. Gage	Form and Size of the Earth
45	July 11	J. A. Pearce	The Sizes of the Stars
46	25	J. Duff	World Explosions
47	Aug. 8	F. T. Stanford	You and the Universe
48	22	R. M. Petrie	Sun Spots
49	Sept. 5	A. McKellar	Nebulae
50	19	J. A. Pearce	The Ursa Major Cluster

REVIEW OF PUBLICATIONS

Die veränderlichen Sterne, von P. ten Bruggencate, with 80 figs. 83 pp.; *Interference Methods in Astronomy*, by F. G. Pease, with 9 figs. 13 pp.

Beginning with 1922 there has appeared an annual volume bearing the title "Ergebnisse der exakten Wissenschaften", prepared by the editor of *Naturwissenschaften*. Each volume consists of papers by leading scientific workers on subjects in which each is a recognized authority. The above are the first two articles in volume X, 1931. The monograph on variable stars is an excellent summary of our knowledge of these objects. In the second paper Mr. Pease gives a sketch of the development of Michelson's method, with the results so far achieved. As Mr. Pease has been chiefly responsible for the design, construction and use of the 20-ft. and 50-ft. interferometers at Mount Wilson his account is authoritative and has a peculiar personal interest. The other papers (all in German) in the volume are on Einstein's new field theory, the dynamical theory of X-ray interference in later form, the Kerr effect, light dispersion and atomic structure, pre-dissociation and related phenomena, the emission of light in the case of collision-excitation; chemical combination and quantum mechanics. The book is published by Springer (Berlin) and of course is typographically excellent. Volume X contains 452 pages and the price is RM 37.60 bound. C. A. C.

Neue Stereoskopbilder vom Sternhimmel, von Robert Henseling. Leipzig: J. A. Barth, 1931.

These pictures for the stereoscope are in three series, illustrating the moon, the solar system, the stars and nebulae. There are twelve subjects in each series and a 16-page booklet for each gives full explanations. Stereoscopic pictures of astronomical objects are hard to obtain and the author is to be congratulated on the result of his efforts. All the pictures (largely photographs) are highly commendable and some are exceptionally good. An English edition of the booklets would add to the circulation among Anglo-Saxons. Price of each series, in cardboard case, RM 8. C. A. C.

NEWS AND COMMENTS

Professor Edward S. King, astronomer for more than forty years at the Harvard College Observatory, died on September 10, at his home in Cambridge, Mass., at the age of seventy years. On September 1, he had retired from the Phillips professorship of astronomy to become professor emeritus.

Mr. Alfred J. Henry, senior meteorologist in the United States Weather Bureau and editor of the *Monthly Weather Review*, died on October 5, aged seventy-three years.

During the last week of July, 1931, Mr. Copley Amory of Boston, Mass., brought together as his guests at his summer home on the Matamek river, north shore of the Gulf of St. Lawrence, about thirty scientists in conference on the problems of cycles in wild life. Dr. Ellsworth Huntington of Yale University, has prepared a comprehensive outline of the varied subjects discussed, which is published in *Science* of September 4.

Dr. Walter S. Adams, director of Mount Wilson Observatory, was elected president of the American Astronomical Society, and Treasurer Benjamin Boss and Secretary Raymond S. Dugan were re-elected. Dr. Willem de Sitter, professor of astronomy and director of the observatory at the University of Leyden, was elected to honorary membership in the Society.

Following the meetings of the American Astronomical Society, December 28-30, the American section of the International Astronomical Union will meet at Washington, D.C.

Dr. George E. Hale has been elected president of the International Council of Scientific Unions (formerly called the International Research Council), succeeding M. Picard.

Dr. Joel Stebbins, dierctor of the Washburn Observatory, University of Wisconsin, has been appointed research associate of the Mount Wilson Observatory for collaboration in stellar photometric studies. Dr. W. H. W. Baade of the Hamburg observatory has been appointed astronomer at the same institution from October 1.

Professor Charles F. Marvin, director of the United States

Weather Bureau, and vice-chairman of the National Committee on Simplification of the Calendar, represented the State Department at the fourth general conference of the Committee on Communication and Transit of the League of Nations at Geneva, Switzerland, on October 12, when the simplification of the calendar was discussed. He also attended the International Meteorological Committee meetings at Locarno, October 5.

Dr. Joseph Papish, professor of spectroscopy at Cornell University and Mr. Eugene Wainer, graduate-student, have announced the discovery of "missing element" No. 87, found in the mineral samarskite, and have secured spectrograms of it. The discovery of element No. 85 was announced earlier in the year by four scientists working at the Alabama Polytechnic Institute. It would thus seem that the list of elements known is complete to No. 92.

Director Harlow Shapley of Harvard College Observatory has announced that construction would begin next spring on the new Harvard observatory to be located on Oak Ridge, Harvard, Mass., 27 miles from Cambridge.

Mr. C. A. French and Mr. R. Glenn Madill have returned to the Dominion Observatory from their terrestrial magnetic observations in the eastern provinces and along the Mackenzie river, respectively.

Mr. G. P. Hatton has returned to the Dominion Observatory from the Onakawan lignite field where he and Mr. A. H. Miller have been co-operating with Ontario officials in investigations of the deposit with magnetometer and torsion balance. Mr. Miller will return in a few weeks.

Director R. Meldrum Stewart of the Dominion Observatory after examining various sites in Quebec for their suitability in observing the total solar eclipse of August 31, 1932, has prepared a report which will be found very useful by those contemplating the observation of the eclipse. Copies of this report may be had by application to the Dominion Observatory. On October 22 he addressed the Ottawa branch of the Engineering Institute of Canada on "Engineering a Solar Eclipse", and on the evening of October 24, members of the branch were guests of the observatory for the inspection of the work of the various divisions.

REDeL.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

A Quarter of a Century

This number of the Journal completes its twenty-fifth volume. For the first eight years (1907-1914) it was published bi-monthly. It was realized, however, that a continuous interest in the Society's work could be better attained by more frequent publication, and beginning with 1915 it has appeared monthly, with the exception of two of the summer months. The war brought difficulties in the form of reduced income and increased cost of production and the latter still persists, especially in the illustrations. A further enlargement of the number of subscribers would improve conditions. The widespread circulation of the Journal has not only united those interested in astronomy in Canada but has also supplied a bond of sympathy with those of like mind all over the world.

It is proposed to publish in the near future a comprehensive index to the twenty-five volumes and also the yearly volumes published by the Society before 1907. This is being prepared by Mr. W. E. Harper, assistant director of the Dominion Astrophysical Observatory at Victoria, B.C. A fuller announcement will be made when an estimate of the cost is available, but we hope to make the price moderate and that there will be a large demand for the volume.

Reminiscences

The previous note and also the celebration, during the past summer, of the centenary of Faraday's discovery of electromagnetic induction and that of the birth of James Clerk Maxwell suggest to the present writer some recollections.

The main facts of Faraday's inspiring life are well known. Born in humble circumstances in 1791, he was apprenticed in 1805 to a bookbinder; and his interest in science was aroused by reading some of the books which he was binding—which practice was encouraged by his master. In 1813 he became assistant in the Royal Institution and in 1825 he was made its director. For forty years he spent all his strength in physical research and his discoveries

were numerous and brilliant. He also had a remarkable gift for popular presentation of his results, and became known as the "prince of experimenters".

It was in 1831 that he discovered the principle of electromagnetic induction, not by accident but as the result of persistent and painstaking experimenting. This principle is the foundation of the enormous industrial development of the dynamo, the motor and the transformer. In explaining how electric and magnetic action takes place Faraday insisted that the medium about the wires and coils and magnets was an essential agent to the production of the observed effects.

Maxwell was a mathematical physicist of peculiar intellectual foresight—almost mystical intuition—and he set out to translate into formulae and equations Faraday's method of reasoning about the medium. He was led to the view that electrical action was transmitted through space with a definite speed which he showed was approximately that of light. Maxwell died in 1879, at the early age of thirty-eight. The experimental demonstration of the correctness of Maxwell's theory was made by Hertz who completely solved the problem in the years 1885 to 1889. Hertz died in 1894 before completing his thirty-seventh year.

Hertz showed electric action was transmitted in the form of waves which had properties similar to those of light waves—that indeed light was an electrical phenomenon. For many years after this electrical waves were the favourite subject for physical research and suitable ways to produce them and to detect them were devised. Among the leading experimenters in this field was Oliver Lodge.

On November 26, 1895, the present writer gave a lecture before the Astronomical and Physical Society (now the R.A.S.C.) on "Electric Radiation," and a full account of it appears in the *Transactions* for 1895. With apparatus specially constructed for the purpose the transmission, reflection, refraction and polarization of the electric waves were exhibited. On February 8, 1896, at a Saturday afternoon lecture at the University of Toronto, he gave an address on "Electric Waves", using the same apparatus. An account of this lecture appeared in the illustrated Saturday edition of *The Toronto Globe* on February 15, and it may be of interest to

state that the young reporter who supplied the report to the newspaper was W. L. Mackenzie King, who graduated in 1895. At the present time these electric waves are so widely used in the wireless telegraph and telephone and the radio, and are such an intimate part of our everyday life, that the writer may be permitted to quote the last portion of his lecture:

> I hope I have shown you that there is radiant electricity as truly as there is radiant light; and, moreover, that they follow similar laws. The present trend of physical theory is seen in the attempt to explain the forces of magnetism, electricity, gravitation, etc., as due to the action of an omnipresent ether. Let me add one more word. Many of you, no doubt, would like to know of any practical application of the great discoveries to which reference has been made. On this side of the ocean we are very prone to ask what is the money value of it, especially when electricity is concerned. The very mention of that word usually calls before the mind pictures of steam engines and dynamos, rattling street cars and brilliant street lamps, unsightly telephone and telegraph poles, or, perhaps, a covetous wish for some of the half-yearly dvidends. But I do not know that a single dollar has been invested to exploit any application of this new principle. The three physicists whose names are most prominent in its development—Faraday, Maxwell and Hertz—are three beautiful examples of men who have freely devoted their extraordinary abilities to the cause of purely scientific investigation, which is indeed the highest interest of mankind, knowing well that "science is, like virtue, its own exceeding great reward".

One can hardly find a better illustration of the truth of the remark that what is the purest of pure science one day may have the most practical of applications to-morrow.

In 1899, on November 25, before the Canadian Institute in its old building on Richmond St., the writer gave a demonstration of wireless telegraphy in which actual messages were transmitted across the room and recorded on paper, by means of the ordinary Morse register.

It is believed that the demonstrations referred to above were the first of the kind given in Canada.

The Red Shift and Distance of Spiral Nebulae

I beg to submit an explanation of the red shift and the linear relation found by Mr. Hubble for the spiral nebulae. First I shall make a short criticism of the explanations already proposed: (1) Shapley supposes the existence of a repulsive force between the Galaxy and the nebulae (Bosler, "Astrophysique", p. 666). If

such a force existed, it would produce an effect that would diminish with the distance, and the facts are exactly opposite. (2) Einstein, de Sitter, Lemaitre, with slight differences, suppose that when we approach the limits of the universe, time and the vibrations of the atoms, as a consequence, would move more slowly (*Opus cit.*, p. 667). To this explanation I will only object, that it presupposes that we are in the centre of the universe, a thing that is not demonstrated. (3) Slipher's explanation is based on the fact, now known to be false, that all of the spiral nebulae, are on the same side of our Galaxy, and then it would be a movement of our own Galaxy; but one fails to see how this would explain the different velocities of nebulae. (4) C. Krafft (*Pop. Astronomy*, Sept., 1931) thinks that the red shift is caused by an expansion of light waves; but this is no explanation. Naturally, if there is a red shift, it means that the waves do expand. (5) It has also been proposed as an explanation that light in its voyage encounters matter, and then the reflection would produce a shift to the red; but to obtain reflection we need opaque matter and then we should have a very large transverse velocity and we also need a very good mirror to see anything at all. Being dissatisfied with the proposed explanations I have thought that it is not so difficult to find a satisfying one by introducing the Einstein gravitation effect. If we admit, as seems natural, that a ray of light in its voyage through space, will pass near more matter if it comes from a greater distance, we find that the Einstein gravitational effect due to mass, will increase with the distance of the luminous object, thus explaining the linear relation found by Hubble. This appears to be a more satisfying proof of Einstein's effect than the somewhat dubious one arrived at by Fabry and Buisson.—*Ulises L. Begara*, Buenos Aires, Arg. Rep.

Midday Observations of Jupiter

Mr. R. H. Spurway of Nelson, B.C., recently observed Jupiter during the daytime with his binoculars, magnifying 8 diameters. In order to pick up the planet, Mr. Spurway selected the conjunction of Jupiter with the moon, which occurred on October 7th, as given in the Observer's Handbook of the Society. The moon was a thin crescent, age 25½ days, being about 4 days before the

new moon. Observing the moon at 11.25 a.m. and again at 12.50 p.m., P.S.T., Jupiter was easily located some 4 degrees to the apparent right, just outside the field of view of the binoculars. The round disc showed very clearly and appeared to have the same colour as the moon. The observations were made under favourable conditions, the sky being beautifully clear.

Mr. Spurway suggests that other members of the Society possessing opera glasses and binoculars try this method of observing the planets during the daytime.

NEW CENTRES OF THE SOCIETY

Arrangements have been completed for the eatablishment of a Centre of the Society at Vancouver. Mr. H. C. B. Forsyth has been very active in the work of organization, and a large list of new members is assured. Negotiations are also being conducted for the formation of Centres at Regina and Edmonton. The Editor wishes them abundant success, and hopes that they will all begin to function on January 1, 1932.

C. A. C.

A Small Observatory for Sale

In the July-August and September numbers of the JOURNAL it was stated that the telescope and observatory of Mr. A. F. Miller were for sale. The former was purchased by Mr. H. Boyd Brydon, Victoria, B.C., but the latter is still unsold. For particulars apply to Charles Potter, Optician, 16 Adelaide St. W., Toronto.

MEETINGS OF THE SOCIETY

At Hamilton

April 14, 1931—The regular meeting of the Hamilton Centre was held in the Public Library Lecture Hall, with the president Mr. J. A. Marsh, in the chair.

Vice-President, Wilfred S. Mallory, M.A., addressed the Centre on "Light", and he treated his subject in a very practical and informing manner.

By using an extended table, well in view of the audience who were gathered around him, the speaker made the fullest use of several mechanical devices to show both the simple and the more involved characteristics of light. The lecture brought out such points as the passage of light, the medium necessary for the transition of light, the fact that light moves in waves and has no mass, its speed of travel, its reflectibility and its refraction. In a very unique way he demonstrated the characteristics of white light, its decomposition into the spectrum and its recomposition into white light again, which phenomena brought in the necessity for explanation of colour and Mr. Mallory did this with a great clearness.

May 12—The regular meeting was held in the Public Library Lecture Hall with the President in the chair, and a good audience present.

"Comets" was the subject of a very interesting lecture by the Rev. Dr. Marsh of Norwich, Ontario, Honorary President of the Centre.

The speaker said that although the study of comets is very interesting and their presence in the sky occasions great interest, little can be learned from them of scientific value. Comets are frequently very large in volume, many times as great as our earth, but very light in mass. Some comets appear, in their journey around the sun, at regular intervals and can be safely said to belong to our solar system but a large nimber of comets visit our sun and vanish, possibly for ever. Most of the meteors we see and meteorites which occasionally fall to our earth, come from the disintegration of comet tails. It is believed that while comets shine with reflected light from the sun that they have also inherent light from bombardment of particles and burning gas.

September 22—The opening autumn meeting held in the Public Library Lecture Hall, attracted a large audience of the members and friends to hear Professor C. A. Chant of the University of Toronto on the subject "Meteors and Shooting Stars".

After hearing the report of the May meeting, given by Miss J. I. Jackson, the president spoke of the outdoor observations of the members during the month of June and said that one hundred and fifty people connected with the Society had made use of the telescope in viewing the heavens.

Professor Wm. Findlay very aptly introduced the speaker of the evening as

being a much quoted authority on astronomy and especially on the subject of "Meteors and Shooting Stars".

Professor Chant first spoke of the number of meteors and shooting stars that might be counted during an evening. Actual observation showed that on an average one could see on a moonless night fifteen per minute in the spring and summer and four per minute in the autumn. Inasmuch as one observer could only see a small percentage of the actual number, the total number that actually bombard our earth's atmosphere would be 100,000 per hour or two and one-half million per day. By close observation it has been discovered that these meteors follow a certain law and radiate for the most part from certain sections of the sky notably from the constellations of Perseus, Leo and Gemini; these meteors taking their name from these constellations, Perseids, Leonids, and Geminids. It has been calculated that the fainter meteors, travelling with great speed, ignite and reveal themselves at about 64 miles above the earth and disappear, that is, are burnt up, at an average of 54 miles above the earth the length of their path being about 36 miles, moving that distance in about one-half a second, so great is their speed. Professor Chant said that all meteors which had been of sufficient size to not be entirely consumed and had fallen to the earth as meteorites could be divided into two classes, stone meteorites and metal meteorites. The latter were composed of about 80% iron and 20% nickel, others all iron. The average shooting star seen is in size about equal to a grain of sand, and is rendered visible by its great speed; others however are very large, some have been found weighing many tons some of which now are on exhibit in the great museums of the country.

The speaker concluded his remarks by a description of the wonderful telescope, the second largest in the world, now being made in England for the University of Toronto, donated by Mrs. Dunlap. This will be completed in about two years.

At London

October 9—A regular meeting of the London Centre was held at 8 p.m. in the London Life Building. There were 66 people present, with one election to membership in the Society, viz., Mr. C. H. Gould, 470 English St., London, Ont.

A brief description of the Engineer's Transit was presented by Professor G. H. Reavely of the Department of Geology, University of Western Ontario. By means of diagrams, Professor Reavely explained how the direction of true north may be obtained by observing the direction of Polaris at greatest elongation.

President McKone next introduced Mr. F. H. Coates of the Department of Biochemistry, Medical School, University of Western Ontario, who delivered an illustrated lecture on "Astronomical Facts of the Great Pyramid". The most remarkable of the Egyptian pyramids are those belonging to the group at Gizeh, four miles south-west of Cairo. The largest of this group, known as the Great Pyramid, is the pyramid of Cheops (King Khufu). The first part of the lecture was devoted to a description of the size and construction of this pyramid, the mmensity of the structure being vividly portrayed by means of lantern slides.

The Great Pyramid has a natural limestone rock foundation, the base of the pyramid forming a square which covers a space of 13 acres. The pyramid is built chiefly of the hard limestone of the district but large granite blocks were also used on the outside. The outer surface of the four walls forms a series of steps, each slightly over three feet in height. The four sides are slightly concave towards the interior, the speaker illustrating this hollowing-in feature by taking a cardboard pyramid and pinching in the four sides at the vertex of the model. The cardboard model which the speaker used had been built in sections, and when these sections were separated there was displayed a cross section of the interior of the Great Pyramid. The entrance into the interior is located in the north face of the pyramid, at the 35th course of steps. The descending passage from this entrance branches, lower down into two tunnels, one, known as the Grand Gallery, is inclined upward at an angle of about 40° from the horizontal and leads into the King's Chamber, a room about 34 feet long, 17 feet wide, and 19 feet high. The second tunnel is inclined downward at an angle of 30° from the horizontal and proceeds to the subterranean Well, located in the base of the pyramid. The original tunnel into the King's Chamber is sealed by a huge block of granite. About 600 A.D. an Arab, Al Mahmoun, in search of plunder, constructed a new tunnel which passed completely over the obstruction in the tunnel leading to the Grand Gallery, and this entry into the inner Chamber of the King is in use to-day.

The speaker expressed the view that the Great Pyramid was planned primarily to reflect the sun's light and secondarily to cast shadows. It was a sun dial not only of the day but also of the seasons, giving accurately the days of winter solstice, spring equinox, summer solstice, and autumnal equinox. The purpose of the hollowing-in feature of the sides of the pyramid was to prevent the diffusion of the reflected light and to stabilize the reflected rays under the influence of variable surface refractions. The beam of light reflected from the south face of the pyramid is truly horizontal on only two days of the year; these two days are midway between the vernal equinox and summer solstice and midway between summer solstice and autumnal equinox. Between these two days the noon reflections from the south face form triangular images on the ground and at no other period of the year is this true. The length of these reflected triangles approaches a minimum at summer solstice, after which the images lengthen again until noon of the last day of summer, when the noon reflection becomes horizontal again.

The lecture was concluded with the remark that in the year 2014 B.C. an observer in the subterranean Well on looking back along the tunnel which leads up to the north face could see the Pole Star of that date framed in the tunnel entrance.

Mr. McKone thanked Mr. Coates for his instructive address. Mr. T. C. Benson discussed by means of charts the constellations Lyra, Cygnus, and Aquila. The meeting then adjourned in order to allow the members to proceed to the roof of the building for outside observations, under the direction of Mr. Benson.

G. R. MAGEE, *Secretary-Treasurer.*

At Victoria

October 27—(Extract from Minutes). Dr. C. S. Beals in the chair.

Mr. George Carter was elected to membership.

The president thanked the members for the tokens of good-will which greeted Mrs. Beals and himself upon their return to Victoria.

The lecture for the evening was by Mr. W. E. Harper, M.A., Honorary President of the Victoria Centre, the subject being "The Astronomy of the Poets".

The lecturer aimed to outline the views held regarding the heavenly bodies from Biblical times to the present in so far as such could be gleaned from allusions made to them by the poets of each succeeding age.

The Hebrew conception of the universe was not scientific in the modern sense of the term, but through a contemplation of the heavens they were led into a purer religion and a more perfect poetry than would otherwise have been the case.

Reference was made to observations of the aurora and meteors in Virgil's day while Dante's "Divine Comedy" gives us a conception of the universe as held in his day about 1300 A.D.

Using the astronomy he found among the common people, Shakespeare imparted to it a poetic radiance and passed it on. About 300 astronomical references are found in his works. The old earth-centred universe was still in vogue, with the various heavenly bodies, each in its own crystalline shell or sphere, rotating about the earth. The soft gliding of one shell over another produced a heavenly strain of music, the so-called "music of the spheres" so often referred to by the poets. While using very beautifully the doctrines of astrology to "point the moral and adorn the tale", passages were quoted to show that Shakespeare recognized the absurdity of the claims of astrologers. In lighter vein the speaker quoted passages from which some might conclude that Shakespeare was familiar with the modern radio.

Though Milton for convenience used the old earth-centred cosmogony as the basis of his *Paradise Lost*, he intimated in his great poem that h is own convictions were that the sun, not the earth, was the centre of our little system.

Many references were made to Tennyson who symbolized the Victorian era of great achievement in science. Passages were quoted showing his belief in the principles of evolution as applied to the physical universe and to man as well.

The lecturer closed with a brief recital of the extraordinary advances of the present day in the realm of astronomy and felt that there must come a twentieth century poet versed in astronomical lore, and with the poetic ability to weave the facts into a great poem which would voice the spirit of our scientific age.

The lecture was illustrated with suitable lantern slides throughout.

P. H. Hughes, *Secretary*.

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